



INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification ⁷ : B65G 53/30, E21F 15/00, 15/08, C09K 7/08, E21B 43/25	A1	(11) International Publication Number: WO 00/51922 (43) International Publication Date: 8 September 2000 (08.09.00)
(21) International Application Number: PCT/EP00/01353 (22) International Filing Date: 21 February 2000 (21.02.00) (30) Priority Data: 60/122,604 3 March 1999 (03.03.99) US (71) Applicant: MBT HOLDING AG [CH/CH]; Vulkanstrasse 110, CH-8048 Zürich (CH). (72) Inventors: GAY, Frank, T.; 9611 Shady Wood Lane, Twinsburg, OH 44087 (US). CONSTANTINER, Daniel; 25416 Bryden Road, Beechwood, OH 44122 (US). CHAMPA, Jeffrey, T.; 23690 Greenwood Road, Euclid, OH 44117 (US). HUTCHINGS, Kevin; 9969 Darrow Park Drive, Apartment 126E, Twinsburg, OH 44087 (US). MILLETTE, Daniel, G.; 309 Aurora-Hudson Road, Aurora, OH 44202 (US). (74) Agent: MCSTEAN, John, Anthony; MBT (Schweiz) AG, Patents and Trade Marks, Vulkanstrasse 110, CH-8048 Zürich (CH).		(81) Designated States: AE, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CR, CU, CZ, DE, DK, DM, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, UZ, VN, YU, ZA, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG). Published <i>With international search report.</i>
(54) Title: TRANSPORT OF SOLID PARTICULATES (57) Abstract <p>A method is provided for incorporating a foaming agent into mixtures of particulates and then forming a foam within the mixture to increase the flowability of the particulates. A method is also provided for excavating solid particulates, incorporating a foaming agent into mixtures of solid particulates, and then forming a foam within the mixture to increase the flowability of the particulates. The particulates can be transported through pipelines or boreholes. Examples of particulates include, but are not limited to, mine tailings, ores, sand, coal, soils, clays, silts, aggregates, and mixtures thereof.</p>		

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TRANSPORT OF SOLID PARTICULATES

FIELD OF THE INVENTION

5 The present invention is directed to transportation of solid particulates. More particularly, the present invention is directed to a single stage method of incorporating a foaming agent into mixtures of solid particulates and then forming a foam within the mixture prior to transport to increase the flowability of the solid particulates.

10 BACKGROUND OF THE INVENTION

Solid particulates, which include but are not limited to mine tailings, ores, sand, coal, soils, and aggregates, have conventionally been transported through pipelines or boreholes as a slurry. Typically, a liquid, such as water, is added to the particulates to make the particulates flow. The particulates are suspended in a sufficient quantity of liquid such that the flow of the liquid moves the particulates through the pipeline.

20 Ideally, the particulates should remain in suspension while being transported through pipelines or boreholes to their final destination. Particulates such as classified or unclassified mine tailings may be characterized by features that limit the ability to transport the material as a paste. Such characteristics may include: high density or specific gravity, poor or gapped gradation, coarse particle size, highly sorted particle size gradation, or lack of fine particles. These features tend to prevent particulates from being made into a stable paste consistency without the addition of fine materials, such as sands, to enhance the particle size distribution.

As a result, these particulates must currently be transported as low-load slurries that must maintain turbulent flow conditions throughout the transport system to prevent the particulates from settling out and clogging the transport pipes. Additionally, the transport fluid may bleed out of the slurry and cause reduced fluidity of the mixture and clogging of the transport pipes.

Reduction of fluid content may produce a material that approaches the consistency

of a paste, but which would also develop reduced turbulence and shear thickening properties. This makes transport by pumping or by gravity through a transport system less desirable and more problematic than by hydraulic transport.

5 One type of particulate transport is the transport of mine tailings as backfill in mines, or to the surface to remove the tailings from the mine. The backfill mine tailings can be transported alone, or a cement can be added to provide for a set composition. It is desired in the art to transport mine tailings as a paste consistency, rather than by hydraulic transport. However, the particle size distribution needs to be optimized to provide paste
10 consistency transportation. The particle size distribution of a mine tailing may be made to conform to a more idealized particle size distribution by the addition of fine materials or sand. This however increases the handling and treatment costs of the mine tailings and increases costs to the mining operations. The ideal fill exhibits slurry-like properties of ease of transport in pipes (i.e., low pressure losses), but paste-like properties of staying in
15 suspension at relatively low transport velocities with no run off.

Once the slurry of particulates arrives at the desired destination, the transport fluid drains out. The fluid must then be pumped away, which adds additional handling and disposal costs to the operation. Additionally, if a cement is included with the particulates,
20 some cement will be present in the drain water which may then harden in the drain system, and increase the maintenance costs of the operation. In the cases where mine tailings are transported to the surface, a dam must be erected to manage and recover the water. This adds additional cost, potential liability, and is a potential safety hazard.

25 Foam suspends the particulates and reduces the amount of liquid required to transport the material. It is known, as in US Patent No. 5,080,534 to Goodson et al., to generate a foam from a surfactant and then mix the foam with the particulates prior to transport in the pipeline. Also, it has been known, as in US Patent No. 4,451,183 to Lorenz, to inject foam which has been separately prepared into the particulates at various
30 points throughout the pipeline. However, these prior art methods require that the foam be separately prepared before being added to the mixture. The separate preparation requires additional equipment and time to prepare the foam, which adds additional cost to the project.

Mine backfilling is the process of filling voids in mines left by the underground excavation of ore to provide structural support for the mine or to dispose of mine tailings. Materials used to fill mine voids include waste rock, mine tailings, and sand. Often, sand is mixed in with mine tailings.

5

Mine tailings are the result of grinding the ore or rock fine enough to liberate minerals through a flotation process. Because of the low content of minerals in the ground rock, typically less than 10% by weight, almost all of the rock mined becomes mine tailings. Mine tailings generally have consistencies similar to those of fine clay or silt.

10 Traditionally, large quantities of water must be added to the tailings to make them pumpable. The tailings at final placement then must be thickened to allow the tailings to set in place. There is a very significant cost to the thickening of mine tailings.

Once the mine tailings are pumped from the mill, they are either sent directly to a
15 tailings pond, sent directly to a backfill plant, or processed with a hydro-cyclone to separate the coarse particles from the finer particles. The coarse fraction is sent to the backfill plant, and the fine fraction is sent to the tailings pond. A tailings pond is generally a large area where the tailings are left to settle and the resulting water is drained off to clarification ponds.

20

A method of producing mine backfill from mine tailings is to process the tailings slurry with a bank of hydro-cyclones to remove the coarser portion of the material. The coarser portion (underflow) is fed into a silo and allowed to settle with some of the water overflowing the top of the silo. The denser tailings material is removed from the silo and
25 pumped to a mixer, where cement is added to produce hydraulic backfill.

The backfill, which is a slurry of typically 50% solids by weight, is poured down a vertical hole or pipe to be deposited in the mining voids or stopes left underground. Because it is a slurry, the backfill requires high volumes of cement to consolidate the
30 material, and water that does exude from the backfill must be pumped out of the mine. The cement contents range from about 3% by weight to about 10% by weight. Using a relatively low percentage of cement requires a much longer time for the backfill mass to be considered "load-bearing" or competent.

Another method of backfill is paste backfill. Paste backfill uses a lower cement content, usually about half of that used in the hydraulic backfill method described above. In addition, there is no water exuded from the fill mass to pump to the surface. The consolidation time is reduced to a fraction of the time required to consolidate hydraulic backfill, allowing a faster cycle time. Another advantage of using paste backfill is that it is usually made from total (unclassified) tailings. This reduces the burden of maintaining a large surface impoundment area.

Paste backfill, however, has some drawbacks. It is more difficult to transport paste to the mine or stopes, sometimes requiring a positive displacement pump to transport the paste through the piping. The production of paste is usually accomplished by processing the mill tailing slurry by using large vat thickeners, disc filters, or a combination of both. This requires a large multimillion dollar capital investment.

What is needed in the art is a foaming agent which can be incorporated into the solids mixture, then to form the foam within the mixture as a single-stage process, to eliminate the separate stages of preparation, pregeneration, and combination of a foam into the slurry prior to transport of the solids as in a pipe.

It is therefore an object of the invention to provide a method of transporting particulates by incorporating a foaming agent in a mixture of particulates and then producing a foam in the mixture prior to transport through pipelines or boreholes as a slurry.

SUMMARY OF THE INVENTION

The present invention also provides a method of excavating and transporting solid particulates comprising: removing the solid particulates from an excavation area; mixing a foaming agent with the solid particulates to form a transportable mixture; adding water and a binder to the transportable mixture; mixing the transportable mixture, water, and binder to form a hydraulic composition; and transporting the hydraulic composition to a desired location.

DETAILED DESCRIPTION OF THE INVENTION

The present invention provides a method of transporting solid materials including providing particulates, adding a foaming agent to form a mixture, and mixing said mixture
5 to form a foam within the mixture.

The benefit of the method of the present invention is that the steps of preparation, pregeneration, and mixing of the foam may be eliminated.

10 The mixing action causes the foaming agent to foam in the mixture. The mixing action may be provided by most commercially-available mixing devices.

The transporting of the mixture may be accomplished by pumping or by gravitational head driven pressure. Another benefit to this method of incorporating a
15 foaming agent into the particulate mixture is that the pressure required to pump the material is reduced. The foaming agent reduces the dilatancy of the particulates in the mixture. The use of the foaming agent therefore allows the pumping of particulates which would have otherwise been unpumpable.

20 The water content of the mixture is less than about 50% based on the mass of the solid material. Preferably, the mixture has a water content of about 5 to 25% to form a paste consistency. The water demand of the material is dictated by the features of the particle size distribution and mineralogy which are unique to each material.

25 Examples of solid materials that which can be transported by the abovementioned method include, but are not limited to, mine tailings, ores, sand, coal, soils, clays, silts, aggregates, and mixtures thereof.

Foaming agents which can be used with the method of the present invention
30 include alkanolamides, alkanolamines, alkylaryl sulfonates, polyethylene oxide-polypropylene oxide block copolymers, alkylphenol ethoxylates, carboxylates of fatty acids, ethoxylates of fatty acids, sulfonates of fatty acids, sulfates of fatty acids, fluorocarbon containing surfactants, silicon containing surfactants, olefin sulfonates, olefin

sulfates, hydrolyzed proteins, and mixtures thereof. A preferred foaming agent is an alpha olefin sulfonate sold under the trademark PS-356 from Master Builders, Inc., Cleveland, Ohio. The foaming agent is added in an amount from about 0.001% to about 0.4% based on the mass of the solid material, preferably about 0.005% to about 0.025%.

5

Preferably, the foaming agent is in the form of a dry powder. This provides ease of handling and improved storability. Liquid foaming agents could solidify in freezing climates, thus necessitating freeze protection or thawing prior to use.

10 Alkanolamide foaming agents according to the present invention include, but are not limited to, those having from about 12 to about 20 carbon atoms

Alkanolamine foaming agents according to the present invention include, but are not limited to, those having from about 12 to about 20 carbon atoms.

15

Alkylaryl sulfonate foaming agents according to the present invention include, but are not limited to, those having one aryl group and having alkyl groups with about 12 to about 20 carbon atoms.

20 Polyethylene oxide-polypropylene oxide block copolymer foaming agents according to the present invention include, but are not limited to, those having about 10 to about 20 units of each block.

Alkylphenol ethoxylate foaming agents according to the present invention include,
25 but are not limited to, those having an alkyl group of about 12 to about 20 carbon atoms.

Carboxylates of fatty acid foaming agents according to the present invention include, but are not limited to, those in which the fatty acid moiety has about 12 to about 20 carbon atoms.

30

Ethoxylates of fatty acid foaming agents according to the present invention include, but are not limited to, those in which the number of ethoxylate groups is about 10 to about 20 and the fatty acid moiety has about 12 to 20 carbon atoms.

Sulfonates of fatty acid foaming agents according to the present invention include, but are not limited to, those in which the fatty acid moiety has about 12 to about 20 carbon atoms.

5 Sulfates of fatty acid foaming agents according to the present invention include, but are not limited to, those in which the fatty acid moiety has about 12 to about 20 carbon atoms.

Fluorocarbon containing surfactant foaming agents according to the present
10 invention include, but are not limited to, those having about 12 to about 20 carbon atoms and one or more CH_2 moieties are replaced by CF_2 moieties.

Olefin sulfonate foaming agents according to the present invention include, but are not limited to, those having about 12 to about 20 carbon atoms.

15

Olefin sulfate foaming agents according to the present invention include, but are not limited to, those having about 12 to about 20 carbon atoms.

Hydrolyzed protein foaming agents according to the present invention include, but
20 are not limited to, the derived products of hydrolysis of proteins. The relative molecular weight of the protein can be any molecular weight that provides for foaming action in a cementitious mixture. Preferably, the relative molecular weight ranges from about 10,000 to about 50,000. Preferred hydrolyzed proteins are hydrolyzed gelatin, hydrolyzed collagen, and hydrolyzed proteins derived from blood. A non-limiting example of
25 hydrolyzed gelatin is TG222 from Milligan & Higgins (Johnstown, New York).

In the method of this invention, the steps of removing the solid particulates from an excavation area and mixing a foaming agent with the particulates to form a transportable mixer preferably occur in a mixing pump.

30

In addition to the foaming agent, there may also be added art-recognized admixtures which have known beneficial effects. These include, but are not limited to: foam-stabilizing agents, water-reducing dispersants, rheology-modifying agents and

accelerators. One or more of such admixtures may be used, either individually or as mixtures.

A foam stabilizing agent may be added to the mixture to stabilize the foam to
5 provide a longer foam life. Foam stabilizing agents which can be used with the present invention include pre-gelatinized starches, cellulose ethers, polyethylene oxides, very fine clays, natural gums, polyacrylamides, carboxyvinyl polymers, polyvinyl alcohols, a nonpolar hydrophilic material, synthetic polyelectrolytes, silica fume, and mixtures thereof. A foam stabilizer may be needed because the transport time in the pipeline could be long
10 and/or the operating pressure in the pipeline may be high, thus compromising the stability of the foam.

Cellulose ether foam stabilizing agents according to the present invention include, but are not limited to, modified cellulose ether.

15

There are many examples of commercially-available polyethylene oxide foam stabilizing agents according to the present invention, one typical example being POLYOX (registered trade mark) range of Union Carbide. It is preferred that the polyethylene oxides have a weight average molecular weight greater than about 500,000.

20

Very fine clay foam stabilizing agents according to the present invention include, but are not limited to, bentonite clay. The definition of very fine clays is meant to include those clays with a particle size less than about 20 microns.

25 Natural gum foam stabilizing agents according to the present invention include, but are not limited to, guar gum, welan gum, and mixtures thereof.

Polyvinyl alcohol foam stabilizing agents according to the present invention include, but are not limited to, those with a weight average molecular weight greater than
30 about 1,000.

Synthetic polyelectrolyte foam stabilizing agents according to the present invention include, but are not limited to, polyvinyl sulfonates with a weight average molecular

weight greater than about 1,000, polyvinyl polymers with a weight average molecular weight greater than about 1,000, and mixtures thereof.

The foam stabilizing agent may be added, either alone or in combination with other
5 foam stabilizing agents, in an amount from about 0.0001% to about 2% based on the mass of the slurry.

Additionally, a water-reducing dispersant may be added to the mixture to disperse the materials and thus allow for a lower water content in the mixture while still maintaining
10 a flowable consistency thus improving the properties of the placed fill material. Water-reducing dispersants which may be used with the present invention include, but are not limited to lignosulfonate salts, beta-naphthalene sulfonate-formaldehyde condensate salts, melamine-containing water reducers, polycarboxylic salts, polycarboxylate copolymers, polycarboxyl amines, polycarboxyl imides, and mixtures thereof. The water-reducing
15 dispersant is added in an amount greater than 0% to about 2% based on the mass of the binder or cementitious system. It should be noted that the dispersant dose rate may also be influenced by the particle size distribution and mineralogy of the solids material being treated, and the chemistry of the admixture.

20 As used herein, the term binder includes those materials which will cause a mixture to set. These include, but are not limited to cements, such as portland or high alumina cements, slags, fly ash, cementitious materials, lime, pozzolans, and mixtures thereof.

Further, any other additives which do not interfere with the properties of the
25 particulate slurry transported by the present invention may be added. These additives may include, but are not limited to, cement, set retarders, set accelerators, lime, fly ash, ground granulated blast furnace slag, and corrosion inhibitors. The amount of binder which may be added is determined by the amount of setting time and compressive strength desired. Typically, the binder or cementitious material is added in an amount greater than 0% to
30 about 30 % based on the mass of the solid material.

An advantage of incorporating a foaming agent into the particulate solids mixture is a reduction in the bleed. Bleeding is the separation of water from the mixture. It is desired

that the water not bleed from the mixture, because that will cause a reduction in the flowability of the mixture. The incorporation of the foaming agent can reduce the bleeding by as much as 100% based on laboratory trials.

5 When the material has been transported to its placement area, the air in the foam may be removed by a variety of methods, if required. These methods include, but are not limited to, mechanical impact as when dropped into a stope underground or when mechanically worked by conventional earth-compacting equipment such as rollers or sheep-foot rollers. In addition, a chemical additive, such as a defoamer, may be
10 subsequently added to the transported slurry, which will cause the foam to collapse, thus removing most of the air voids from the foamed material.

 In another embodiment of the present invention, a method is provided to excavate solid particulates, transform the solid particulates into a paste-like consistency, and then
15 transport the solid particulates to a placement area. First the solid particulates are removed from the excavation area by a pump and the foaming agent is mixed in. Some water may be necessary to break up the solid particulates to allow initial pumping; however, the amount of water needed does not generally exceed an amount that would lower the total solids below paste consistency.

20

 The foaming agent may be added to the solid particulates in a mixer separate from the pump, or a mixing pump can be used. An example of a mixing pump is the Toyo DP/DL wet end pump. This type of pump is a submersible, bottom suction pump with an agitator and water supply at the bottom. In this pump, water is fed to the agitator to break
25 up thick materials or sludge and convert it to a paste to allow initial pumping. The pump is fitted with a nozzle to inject the foaming agent, or any other desired admixture, in the agitator portion of the mixer pump. The foaming agent is injected by use of a carrier, which can be water, compressed air, or any other gas. If the foaming agent is a dry powder, it can be dissolved in a water stream, or it can be blown in with the gas.
30 Alternatively, a pre-generated foam can be used in place of the in-situ foaming agent embodiment. The foam provides the pumpability of the transportable mine tailing mixture slurry.

The pump is moved about the excavation area to remove the solid particulates. Any suitable method of moving the pump is satisfactory. The pump may be suspended from a barge or a crane. Alternatively, the pump may be suspended from a two-dimensional cable pulley system which covers the excavation area. Such a cable pulley system typically includes parallel opposed pulleys with a pulley mounted transversely between the parallel pulleys. The pump can move side to side on the transverse pulley and end to end on the parallel pulleys.

From the excavation area, the foamed solid particulates are transported to a backfill plant. At the backfill plant, binder is added to the foamed solid particulates. The water content of the incoming foamed solid particulates is measured with a moisture analyzer. If necessary to achieve the desired total solids level in the final solid particulates binder mixture, water can be added to the mixture. The amount of water is calculated based on the total solids of the incoming foamed solid particulates.

15

Traditionally, a pug mixer with two counter-rotating mixer screws, variable speed drive, and adjustable pitch blades is used to mix binder and optional water into the solid particulates to form a hydraulic solid particulate composition. After being mixed, the hydraulic solid particulate composition is transported to the placement area by gravity feed or by pumping.

20

In the above embodiment, the excavation area can be a mine tailings pond, the solid particulates can be mine tailings, and the placement area can be a mine or a stope.

When referring to a mine throughout this specification, it is also meant to include a stope.

25

EXAMPLES

The invention can be described by the following non-limiting examples. In the examples set forth below, slump is measured by ASTM C143 and C143M. Density is measured by placing the mixture into a 400ml cup. The tare weight of the cup is 749g.

30

Mix A

40kg wet mine tailings

12

1.2kg cement-Portland Cement from Lafarge

4kg water

Total weight of mixture and cup 1738.5g.

Density=989.5g/400ml

5

The water content is varied to determine the slump.

Total water at 5.4kg: slump: large cone 11.3 cm

Total water at 6kg: slump: large cone 17.8 cm

10

Mix B

40kg mine tailings

1.2kg cement-Portland Cement from Lafarge

3.9kg water

8.96ml of a polyoxyalkylene derivatized methacrylate polymer*

15

5.0ml of a polyoxyalkylene derivatized methacrylate polymer*

Total weight of mixture and cup 1741.8g.

Density=992.8g/400ml

* - Polymer is FC-900 from Master Builders, Inc., Cleveland, Ohio

20

Next, a pre-generated foam is added to the mixture.

Slump of the mixture with foam large cone 14 cm small cone 4.4 cm

Total weight of mixture and cup 1510.3g.

Density=761.3g/400ml

25

Next, mixtures are prepared and tested as a plain reference and then with foaming agents added. The slump and density of the mixtures are tested, then test cylinders are prepared to test bleeding and compressive strength. There are prepared 4 7.6 cm x 15.2 cm cylinders, with 1 cylinder to measure bleedwater, and 3 for compressive strength determination.

30

Set 1

45kg mine tailings @10.9% moisture

1.335kg cement-Portland Cement from Lafarge

6.6kg water is added to bring the pulp density to 72% solids.

1A

Slump large cone 19 cm

5 Total weight of mixture and cup 1571.9g.

Density=822.1g/400ml

Note: The material segregates and bleeds rapidly.

1B

10 To the Set 1A mixture, 9ml of a 15% solution of a modified cellulose ether is added.

Slump large cone 19 cm

Total weight of mixture and cup 1549.1g.

Density=800.1g/400ml

15 Note: The material segregates and bleeds.

1C

To the Set 1B mixture, 10g PS-356 is added as a foaming agent.

Slump large cone 17.8 cm

20 Total weight of mixture and cup 1469.6g.

Density=720.6g/400ml

Note: The mixture is stable and does not segregate.

Set 2

25 The mixture is prepared as per Set 1, but with 5.4 kg additional water to produce a pulp density of 74%.

2A

To the Set 2 mixture, a modified cellulose ether @8.87% or 1.88 g/kg of cement;
and

30 a water reducing foam stabilizer @8.87% or 1.88 g/kg of cement; and
10g PS-356 are added.

Slump large cone 7.6 cm

Total weight of mixture and cup 1427.5g

Density=678.5g/400ml.

2B

To Mixture 2A, 1.2kg of water is added to yield a pulp density of 72%.

5 Slump large cone 15.9 cm

Total weight of mixture and cup 1421.2g.

Density=672.2g/400ml

Note: Slight bleeding is observed

10 The results of compressive strength and bleed testing for the above examples are listed below in Table 1.

TABLE 1

Sample	Bleed Test (ml of water) (cumulative)		Compressive Strength (MPa)	
	@4-5 hours	3 days	3 day	28 day
1A	22.5	50.5	0.26	2.39
1B	15	38	0.23	2.61
1C	3	12		1.69
2A	0	0	0.15	1.97
2B	3	3	0.12	1.76

15 Mix 1A shows the typical characteristics of an untreated slurry. Table 1 shows a high amount of bleeding in that Mix 1C a nearly 90% and 80% reduction in bleeding with the addition of the foaming agent and foam stabilizer at 4 to 5 hours and 3 days, respectfully. Mix 2A shows a combination of water reducer, several foam stabilizers, and foaming agent that produced a mix that did not bleed. Also, Table 1, shows that all of the
20 mixtures achieved an acceptable compressive strengths.

EXAMPLE 2

Three tests of mine tailings are made with PS-356 foaming agent supplied by Master Builders, Inc., Cleveland, Ohio.

25

The moisture of the mine tailings is approximately 14% by mass of the solids with a consistency of a loose, moist sand which has a "packing" consistency and will not flow as a liquid.

In Test #1, 1000 grams of the mine tailings is mixed with 0.25g of PS-356 in a Hobart mixer. After approximately one minute of mixing, the material produces a mud-like quality which allowed the material to flow and could be pumped. With continued mixing, the density of the mix is reduced with further mixing as shown in Table 2 below.

5

In test #2, 1000 grams of the mine tailings is mixed with 0.1g of PS-356 in the Hobart mixer. After approximately one minute of mixing, the material produces a mud-like consistency which flowed and is pumpable. With continued mixing, the density of the mix is reduced as shown in Table 2 below.

10

In test #3, 1000 grams of the mine tailings were mixed with 0.05g of PS-356 in the Hobart mixer. After approximately one minute of mixing, the material produced a mud-like consistency that flowed and was pumpable. With continued mixing, the density of the mix was reduced as shown in Table 2 below.

15

TABLE 2

Mix Time (min)	PS-356 0.25g dose		PS-356 0.1g dose		PS-356 0.05g dose	
	Mass/400ml	Mass/ml	Mass/400ml	Mass/ml	Mass/400ml	Mass/ml
0	856	2.14	856	2.14	856	2.14
1	427.6	1.818	560.5	1.4	637.1	1.59
2	407.8	1.019	508.4	1.27	645.9	1.61
3	358.7	0.896	502.6	1.25	665.4	1.66
4	323.1	0.807	503.8	1.26	not tested	not tested

The tests results in Table 2 show that the addition of the foaming admixture can convert a tailing material with little free moisture into a material that has fluid properties when converted to a foamed mixture. The resulting material has lower density and better flow characteristics than the original moist tailings starting material.

It should be appreciated that the present invention is not limited to the specific embodiments described above, but includes variations, modifications and equivalent embodiments defined by the following claims.

CLAIMS

1. A method of transporting particulates comprising,
providing particulates;
5 adding a foaming agent to form a mixture; and
mixing said mixture to form a foam within the mixture.
2. A method according to claim 1, wherein the mixture has a water content of less than about 50% based on the mass of the particulates.
3. A method according to claim 1 or claim 2, wherein the foaming agent is in the form
10 of a dry powder.
4. A method according to any one of claims 1-3, further comprising adding a foam stabilizing agent and mixing said mixture.
5. A method according to any one of claims 1-4, further comprising adding a water reducing dispersant to the mixture and mixing the mixture.
- 15 6. A method according to any one of claims 1-5, further comprising adding a binder to the mixture.
7. A method according to claim 6, wherein the binder is added at least one of prior to the mixing step and after the transportation step.
8. A method of excavating and transporting solid particulates comprising:
20 a. removing the solid particulates from an excavation area;
b. mixing a foaming agent with the solid particulates to form a transportable mixture;
c. adding water and a binder to the transportable mixture;
d. mixing the transportable mixture, water, and binder to form a hydraulic
25 composition; and
e. transporting the hydraulic composition to a desired location.
9. A method according to claim 8, wherein adding further comprises adding an admixture.

10. A method according to claim 9, wherein the admixture is selected from the group consisting of foam stabilizing agent, water reducing dispersants, rheological modifying agents, accelerators, set retarders, corrosion inhibitors and mixtures thereof.

INTERNATIONAL SEARCH REPORT

International Application No

PCT/EP 00/01353

A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 B65G53/30 E21F15/00 E21F15/08 C09K7/08 E21B43/25

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 B65G E21F C09K E21B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	GB 2 090 823 A (FOSECO INT) 21 July 1982 (1982-07-21)	1
A	page 1, line 37 -page 1, line 55; claim 1	8
A	US 4 419 135 A (HOGE JOHN H) 6 December 1983 (1983-12-06) example 2	1,8
A	EP 0 114 448 A (TILCON LIMITED) 1 August 1984 (1984-08-01) page 1, line 13 -page 1, line 24 page 7, line 1 -page 7, line 6	1,8

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

* Special categories of cited documents :

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"&" document member of the same patent family

Date of the actual completion of the international search

26 May 2000

Date of mailing of the international search report

09/06/2000

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INTERNATIONAL SEARCH REPORT

Information on patent family members

Int'l. Jonal Application No

PCT/EP 00/01353

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